A STUDY OF THE ECOLOGY AND REACTIONS OF FOUR SPECIES OF ACRIDIDAE

BY

HARRY LEE ANDREWS
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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Harry Lee Andrews.

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Victor E. Shelford
In Charge of Thesis

Henry B. Ward
Head of Department

Recommendation concurred in:*

Committee
on
Final Examination*

*Required for doctor's degree but not for master's.

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A STUDY OF THE ECOLOGY AND REACTIONS OF FOUR SPECIES OF ACRIDIDAE.

I. INTRODUCTION.

The material here presented is based on field observations and laboratory study during the past two summers on four species of Acrididae. In an attempt to make a census of the animal population of a plot of ground, my attention was called to the predominance of Orthopteran life. Field observations revealed not only variety in species and predominance in number of individuals of this order, but also a tendency towards segregation of species into associations.

Many attempts have been made in connection with taxonomic papers to list Orthoptera according to the vegetation upon which they are found, and to explain their distribution as due to the distribution of their food plants.

It is the purpose of this paper to call attention to some environmental relations of greater ecological importance than food, thus accounting for the formation of associations in terms of behavior.

II. LOCALITIES STUDIED.

The area studied is located one mile north of Urbana along a drainage ditch. The soil is clay having been placed there in the digging of the ditch. Four distinct stations were studied.

First, the brook margin or a narrow strip of land bordering the creek supported a luxuriant growth of willows, smart-weed, cockle-burrs and water grass.

Second, the clay bank which consisted of a rather steep slope at the base of which was a regular incline adjoining the brook margin. The vegetation here was sparce. An occasional wild lettuce plant, a scrubby growth of rag-weed, and now and then a small patch of rather dwarfed white clover struggled for existence. Near the top of the steep slope was overhanging sod and an occasional piece had moved down the bank by slumping.

Third, the top of the bluff or the sweet clover association was almost level. On the ground stratum was largely blue-grass supporting also a rank upper growth of sweet clover, wild lettuce, burdocks and thistles.

Fourth, farther down at a turn in the stream was a temporary marsh or mud bank exposed only at low water, and hence supporting no vegetation except water grass. Here much debris and sediment had been deposited by occasional floods.

1. Brook Margin Association.

Each region had its predominating specie. On the brook margin were found nymphs of all sizes and adults of *Melanoplus differentalis*. Besides *M. differentalis* was an occasional *M. bivittatus*, a few forked tailed katydids (Scudderia furcata), a few short horned locusts (Orphulella speciosa), and the short winged green locust (Dichromorpha viridis). The dense growth and moist ground formed a cool habitat. The *M. differentalis* were by far in the majority in numbers. The above named varieties were found occasionally while *M. differentalis* were on every stem. The nymphs chose the ground stratum and flat leaf surfaces, while the adults were perched on the largest stems. When frightened they moved to the opposite side of the stems, usually flying to another stem about three or four feet away then dropping into the tall grass soon becoming concealed. They are poor flyers usually moving by combination of jump and flight.

2. Clay-Bank Association.

The clay bank had its distinctive population. *Dissosteira carolina* predominated. A few locusts (Psinidia fenestralis) were observed in this habitat. Their yellowish color closely resembling the clay back-ground afforded excellent protection. *D. carolina* seem to collect in small groups. While

catching them for study in the laboratory, I found that from three to five, sometimes eight were usually near together. When one flew up on my approach, the others seemed to take warning, the others following closely the flight of the first to a distance sometimes ten feet away or further. When in groups they do not fly such great distances when pursued as when alone. The females are more solitary than the males. Observing several of these small groups, I found them to contain all males. This and other observations, I am inclined to believe that the males are somewhat more gregarious.

When any object approaches they fly up alighting only a few feet away with head pointing toward the approaching danger. If danger follows they fly greater distances, each time flying higher alighting a much greater distance away. *D. carolina* make much less resistance when captured than the other forms. They seldom emit the so called "tobacco juice."

I observed one male making a rather spectacular flight. It flew upwards about six feet and rapidly vibrating its wings it was able to remain almost stationary for a few seconds. I observed others in such flights but were unable to capture them in order to determine whether the movements were made by both males and females.

Dissosteira carolina have very good eyesight for seeing objects ahead or at the side. They are able to distinguish objects approaching at a distance of ten or twelve feet. On one occasion a large burdock quite concealed me from the locusts view. I approached sufficiently close to have captured it with

my hand. Another instance one alighted in a gulley, alighting head downward on the slope. I was able to approach within two feet without being seen.

5. Sweet Clover Association.

In the sweet clover association nymphs and adults of Melanoplus femur rubrum were in excess. A sweep of the net would capture an occasional cone-head (Conecephalus robustus), and a few forked-tailed katydids (Scudderia furcata). I also found one oblong winged katydid (Amblycorpha oblongifolia). M. femur rubrum were in great majority. The nymphs by hundreds populated the ground and lower strata. Medium sized nymphs were more venturesome and were usually found on plants that were one-half to a foot high. They were most numerous on the broad leaves of the thistle. The adults were usually on the stems in the very tall sweet clover plants. They were very timid, and upon approach took the opposite side of the stems. Testing them with crude devices in the field, I am inclined to believe that M. femur-rubrum depend much upon eyesight rather than hearing to tell the approach of danger. If approached directly from the side or above, they fly when one is within four or five feet, but when approached from below it is an easy matter to collect them by hand.

It is interesting to watch their methods of alluring their pursuers. Frequently, they will jump and proceed by flying a yard or two to another plant. They at once try to conceal themselves by crawling to the opposite side of the stem. Many times they will drop to the ground and by crawling a short distance in

the grass are safely concealed. In case they are discovered in this hiding place, it is interesting to note how easily they are captured. They seldom make any attempt to escape, and remain quiet until picked up. As soon as danger has passed, they crawl to the nearest plant and are seen in their former positions.

When danger approaches the flight of one grass-hopper seems to warn others. I have counted fifteen to twenty grass-hoppers in retreat. In all cases observed, I am sure the retreating followers were sufficiently far away that they did not detect my approach. They always follow in the direction of the first.

4. Temporary Marsh Association.

In the temporary marsh were found many *Tetrix granulata*. They inhabit the ground stratum. They are poor fliers usually escaping their pursuers by a hop combined with flight. They hop only a short distance, perhaps a foot. Their close resemblance to the ground and by crawling under the debris, they are not easily observed.

III. OBSERVATIONS IN ENVIRONMENT.

Grasshoppers have their enemies and diseases. During the early part of my observations, I found several grasshoppers affected with fungus disease. They had usually crawled to the tops of plants taking a firm grasp and were found hanging where they had died. Many of the specimens kept in the cage in the

laboratory died similarly. Sometimes a grasshopper in random flight will become entangled in a spider webb. I noticed many cases where spiders seemed to lay in waiting in their beautifully constructed webs, for such accidental happenings to take place, rushing out on the trespasser and proceeding to entangle him further. *M. femur rubrum* meet this death frequently. I have also found large *M. differentalis* and *M. bivittatus* entangled.

I found wasps capturing nymphs, and carrying them away. Locusts are also victims of Diptera parasites. While keeping some live specimens in vials for identification two large Dipterus larvae crawled out of the posterior end of a *M. differentalis*. The locust seemed very sluggish when I placed it in the vial and died soon after the larvae had left the body.

Moulting is an interesting process and very easily observed both in the field and in the laboratory cages. It is a much easier and a more rapid process in the large sized nymphs than in the small nymphs. One small nymph became very sluggish during an experiment. As its actions were not normal, it was removed from the experiment pan. It soon began moulting which process was long and tedious. It worked and struggled for one and one-half hours. Later observation showed that it had not been able to extricate itself but had died in the process. Large nymphs observed moulting in the field attach the claws of the third pair of legs to a twig and hanging head downward, the process soon begins and is completed in about twenty minutes. The observed extremes were eight and thirty-two minutes.

The observation that certain species of insects are

commonly found in the same associations as certain plants, does not justify the conclusion that the insects are there because they feed upon the plants. Looking into the habitat, we find nymphs and adults choosing different strata, different positions, different food plants. Such observations have led to experimental work in order to interpret the relation of animals in their normal environments in terms of their physiological constitutions.

IV. EXPERIMENTAL RESULTS.

1. Reactions to Light.

A great number of experiments were carried on in the field and laboratory in studying light and its effects. The apparatus used has been described by Shelford ('17). It consists of pans 10x30 centimeters at the bottom with slightly larger tops and about 7 cm. deep, painted black. Glass tubes with hemispherical ends and caps were used as containers. One third of the inside circumference which is placed downward is painted black. A cover with an adjustable slit was used to allow bright light, medium light, and shade divisions to strike the container.

In the experiments usually five or ten grasshoppers were used. Readings were recorded every five minutes until twenty had been taken. In cases where data did not seem conclusive five experiments were run and averages made. In other cases only the most representative data will be given.

Experiments in phototaxis show that grasshoppers do not all exhibit the same responses. One species may respond in one way, another in another manner. Nymphs may react very differently than the adults of the same species. In tests with adults of Melanoplus femur rubrum, Dissosteira carolina, and Melanoplus differentialis, D. carolina and M. femur rubrum were positive to light while M. differentialis was negative.

D. carolina		M. femur rubrum		M. differentialis	
Light	Dark	Light	Dark	Light	Dark
69%	31%	66%	34%	34%	66%

It is noticeable that the nymphs of M. *femur rubrum* and D. *carolina* do not respond to light as do the adults, but in both species the adults are found to be positive and the nymphs negative.

Adult M. *femur rubrum*		Nymphs of M. *femur rubrum*	
Light	Dark	Light	Dark
66%	34%	38%	62%

Adult D. *carolina*		Nymphs of D. *carolina*	
Light	Dark	Light	Dark
71%	29%	40%	60%

It is significant that the difference in reaction between the nymphs and adults of these two species corresponds with the difference in light conditions in the localities in which the two stages are found. Thus the adults of M. *femur rubrum* were usually exposed to light on the tops of the stalks of sweet clover, while the nymphs were hidden on the under sides of the leaves of plants of the low growth or among the grasses. Similarly the adults of D. *carolina* were found on the bare clay banks exposed to the direct rays of the sun, while the nymphs were invariably found in the partially protected situations formed by sparse growth of clover, ragweed, and similar vegetation near the foot of the clay bank.

In contrast to the above two species, the adults and nymphs of M. *differentialis* are alike in their reaction to light, both being negative.

Adult M. *differentialis*		Nymphs of M. *differentialis*.	
Light	Dark	Light	Dark.
[illegible]%	50%	30%	70%

Here again the responses under experimental conditions are what would be expected from the character of their habitat for both nymphs and adults are confined to conditions of moisture and shade.

Experiments in direct light when heat becomes a factor as was the case of some experiments run at noon, show a negative reaction toward light in all species tested except *Dissosteira carolina*. When heat became intense the adults of this species died. None of the nymphs died. (This would indicate that the nymphs were able to stand greater temperatures than the adults.

(a) Intensity and Direction.-- Experiments in intensity and direction were performed in the dark room in the vivarium with the [illegible] light gradient, (described by Shelford '14). It was found that in some cases the young and adults of a species react alike, while in others the reactions are reversed. The number of specimens used and readings taken were the same as in former light experiments.

Melanoplus femur rubrum	Direction		Intensity	
	Light	Dark	Light	Dark
Very small nymphs	42	60	41	56
Second & third stage	34	66	40	60
Last stage	73	28	71	24
Adult	64	53	65	72

Small nymphs of M. femur rubrum are negative to direction and intensity. Adults are positive to direction and intensity.

Melanoplus differentialis	Direction		Intensity	
	Light	Dark	Light	Dark
Very small nymphs	44	56	24	76
Second & third stage	38	62	20	70
Last stage	34	66	42	58
Adult	52	48	41	59

Nymphs and adults of M. differentialis are negative to direction and intensity. Adults are less negative to direction, nymphs are less negative to intensity.

Dissosteira carolina	Direction		Intensity	
	Light	Dark	Light	Dark
Nymphs	88%	12%	76%	24%
Adults	64%	36%	66%	34%

Both nymphs and adults of *D. carolina* are strongly positive to both intensity and direction.

Tetrix granulata	Direction		Intensity	
	Light	Dark	Light	Dark
Adults	51% -	49%	25% -	75%

Tetrix granulata is somewhat indifferent to direction but negative to intensity.

No experiments were performed with nymphs of *Tetrix granulata* because the early stages of this form were not available at the time this work was in progress.

Here, again as in case of the experiments on phototaxis, we find an exact correlation between the reaction of the insects and the conditions in the habitat in which they occur.

(b) Reactions to Colors.-- An attempt was made to find out reactions of grasshoppers to the different colors of the spectrum in order of phototrophic power. A cover for the container was made from colored gellatine sheets and arranged in the order,-- violet, blue, green, yellow, orange, and red. The light was furnished by a forty watt Mazda.

COLOR TESTS.

	Adults						Nymphs					
	V.	B.	G.	Y.	O.	R.	V.	B.	G.	Y.	O.	R.
Melanoplus femur rubrum	0	7	26	46	8	17	5	7	35	24	10	10
Melanoplus differentialis	10	12	17	19	16	28	1	10	19	18	38	35
Dissosteira carolina	12	10	30	26	15	9	17	13	30	12	16	6

There is a general preference for green and yellow in both nymphs and adults of *Melanoplus femur rubrum* and *Dissosteira carolina*. The nymphs and adults of *Melanoplus differentialis* prefer orange and red. This is in agreement with other light reactions in which insects prefer shade or darkness.

2. Reactions to Surface

Field observations show that grasshoppers vary in the kinds of resting places which they choose. There is a distinct difference in the species as well as a difference in adults and nymphs of a species. For example, *Dissosteira carolina alights* on the bare ground, *Melanoplus differentalis* usually on stems. The nymphs of *M. differentalis* or *M. femur rubrum* are usually found on leaf surfaces, while the adults prefer stems. Experiments testing this point were carried on using the apparatus described by Shelford '17. As stimuli I used square sticks of mint, round stems of plants, strips of corregated paper, mica, pebbles, quartz, and sand. The readings were taken as in the light tests.

D. carolina		*M. femur rubrum*		*M. differentalis*	
Smooth surface	Sticks	Smooth surface	Sticks	Smooth surface	Sticks
78%	22%	44%	56%	32%	68%

D. carolina showed no preference for the sticks. They crawled over the sticks, always taking the smooth surface of the pan in preference to crawling on the sticks. *Femur rubrum* always followed the sticks after coming in contact with them. In very few cases did *M. femur rubrum* walk on the smooth surfaces of the pan. *M. differentalis* also showed a decided preference for the

sticks. In experiments in which I used large, small, and square sticks, *M. differentalis* seemed very active when on sticks of small circumference, but became very quiet when on sticks of larger circumference.

In experiments with nymphs and adults of *M. femur rubrum* in which mica was used as a stimulus, I found that the adults showed a preference for the bits of mica. They would crawl from the bits of mica to the smooth surface, immediately turn around and become quiet in the small surfaces of the mica. The nymphs seemed to show little preference for the mica.

Adults *M. femur rubrum*		Nymphs *M. femur rubrum*	
Mica	smooth surface	Mica	smooth surface
76%	24%	36%	64%

I next tested nymphs and adults with sticks of corrugated paper, square sticks of wood, and triangular sticks of wood.

Adults *M. femur rubrum*		Nymphs *M. femur rubrum*	
Sticks	smooth surface	Sticks	smooth surface
74%	26%	[illegible]	[illegible]

The adults prefer the round surfaces, the nymphs the flat.

5. Reactions to Temperature.

Temperature plays an important part in the life of a grasshopper--some choosing cool shaded habitats, others dry warmer places.

In the experiments gradients were established and maintained by placing two pans on the water table and allowing hot water to flow into one, cold into the other. A third pan was set across these two so as to allow the water to pass in contact with the cold at one end and the warm at the other, (Shelford '17). Sand and black dirt were used as a floor in the pan. Temperatures of 50° C. (hot) and 25° C. (cold) were maintained.

Adults *M. femur rubrum*		Nymphs *M. femur rubrum*	
hot 50°	cold 25°	hot 50°	cold 25°
67%	33%	46%	54%

The nymphs were very inactive and seemingly disturbed in either temperature. All experiments showed a slight preference for cool temperatures. Nymphs of *differentialis* were most negative to heat.

I next subjected adults to the same temperatures.

D. carolina		M. femur rubrum		M. differentialis	
Hot 50°C.	Cold 25°C.	Hot 50°C.	Cold 25°C.	Hot 50°C.	Cold 25°C.
89%	11%	60%	40%	29%	71%

D. carolina moved out of the cool regions to the jar and became inactive in the warm area. M. differentialis was much agitated upon coming into the warm area. They would either turn directly around moving to the cool area, or jump ahead into the warm area moving about actively, finally finding their way out or jumping to the cool area. M. femur rubrum were not so active as either D. carolina or M. differentialis. They are slightly positive to heat. Adult specimens of M. femur rubrum when subjected to high temperatures die much before the nymphs seem to give any signs of agitation.

4. Reactions to Gravity.

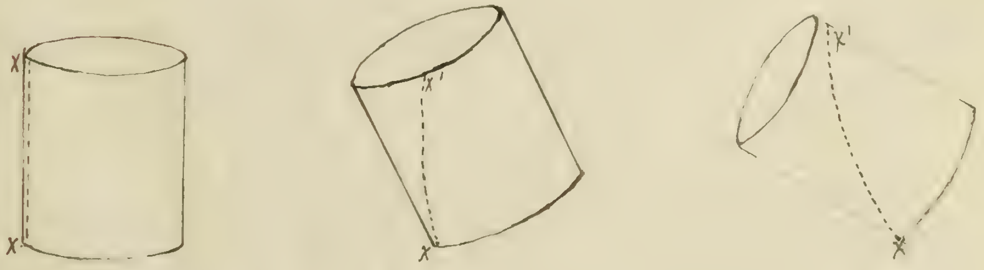
Experiments in geotaxis did not show very decided results. *M. femur rubrum* and *M. differentialis* are undoubtedly negatively geotactic. Phototactic stimuli seem to be greater in effect, consequently altering the grasshoppers response to gravity.

M. femur rubrum and *M. differentialis* crawl up the stem and upon reaching the top they jump usually alighting on the ground sometimes on a stem that is nearer the surface than the former position. They then proceed to crawl up again. Tests in which I used *D. carolina* indicate a decided positive geotactic response. This species which in nature is found on the ground remain on the floor of the container.

(a) Orientation.-- Grasshoppers usually orient head upward on the stem. I placed *M. femur rubrum* in a cylindrical wire cage. Laying the cage on the side, the grasshopper took a position on the end of the cylinder with the head upward. As the cage rotated, the grasshopper moved, always walking in a circle and always keeping the head upward. When the cage was moved faster than the grasshopper's rate of movement, it would jump to another position in the cage. The test was made on several specimens, all of which responded in the same way, always moving in a circle and moving in the direction that the cage was rotated.

I next placed the cage on the side rotating it slowly. This time the grasshopper was on the side of the cage. I turned the cage about fifteen degrees so that the grasshopper would be on the side of the cage but with the head downward. At once it walked forward. Rotating the cage I was able to keep it relatively in the same position. After a time, being unable to walk to a position where it would be normally oriented, it jumped taking a position head upward. This experiment was repeated with the same results.

I next placed the grasshopper on the bottom of the cage, this time slanting the cage at an angle of fifteen degrees. It traveled upward in a spiral path arriving at the top at about fifteen degrees from the former position. If the cage was slanted at a greater angle the path traveled became greater forming a greater angle.



X - First position of the grasshopper.
X'- Position taken by the grasshopper.

5. Experiments in Evaporating Power of Air.

Experiments were performed to determine the reactions of the grasshoppers to air of different evaporating powers. The apparatus used was essentially the apparatus described by Shelford and Deere (1913), Hamilton ('17), and Weese ('17). The experiments covered a period of forty minutes, readings being taken every two minutes. Five animals were used.

The grasshoppers show a dislike for either moist or dry air currents. When first placed in the gradient cage they are very active. Finally they arrange themselves on the wire screen opposite the entrance of the air currents and become quiet. If they come to rest on the floor of the cage, they orient with the head away from the currents of air. This would show them to be negatively anemotropic.

The data given below was taken on _M._ _femur_ _rubrum_ nymphs and adults. In all species there is a tendency to show a preference for dry air, nymphs showing a greater preference than adults. The data given is typical for all species studied.

Adults.

Minutes	Humidity 80	55	25
1	3	1	1
2	1	3	1
4	3	1	1
6	2	1	2
8	2	1	2
10	0	5	0
12	2	2	1
14	3	1	1
16	2	2	1
18	2	2	1
20	0	0	5
22	0	2	3
24	1	3	2
26	1	2	2
28	1	2	2
30	1	1	3
32	0	2	3
34	0	2	3
36	0	2	3
38	0	2	3
	25%	38%	37%

Nymphs.

Humidity 80	55	25
0	2	3
1	2	2
1	2	2
2	2	1
1	1	3
1	0	4
2	0	3
2	0	3
2	0	3
1	0	4
2	0	3
2	1	2
3	0	2
1	2	2
1	0	4
1	0	4
1	0	4
1	0	4
1	0	4
1	0	4
27%	12%	61%

V. CONCLUSIONS.

Grasshoppers tend to form associations. This habit is little affected by choice of food, but rather according to response to light, surface contact, temperature, gravity, and the evaporating power of air.

Nymphs and adults select somewhat different habitats and show a corresponding difference in their reactions to environmental stimuli. Thus, nymphs choose broad, flat leaf surfaces of the lower strata, adults take positions on the stems.

Four stations were studied: the brush margin, clay bank, sweet clover, and temporary marsh. Each station has its distinctive species. *Melanoplus differentalis* is found in the brush margin; *Dissosteira carolina* on the clay bank; *Melanoplus femur* rubrum in the sweet clover; *Tetrix granulata* in the temporary marsh.

The following table briefly summarizes the reactions of the grasshoppers to the various factors of their environments. These reactions as has been repeatedly pointed out are correlated with the differences in the habitats chosen by the various species and stages of development as observed in the field and may be regarded as explaining the distribution of the grasshoppers in their natural environment.

Table Showing Reactions to Environmental Stimuli.

Stimuli	M.differentialis Brook margin		M.femur-rubrum Sweet clover		D.carolina Clay bank		T.granulata Marsh
	Adults.	Nymphs.	Adults.	Nymphs.	Adults.	Nymphs.	Adults.
Light	N	N	I	N	I	N	I
Intensity	N	N	P	N	P	P	I
Direction	N	N	I	N	P	P	N
Colors	(Orange & red)		(Green & yellow)		(None)		(None)
Rough surface	I	N	I (Slightly)	N	N	N	N
Temperature	N (To warm)	N	P (To warm)	I	I (To warm)	I	N (To warm)
Gravity	I	N	I	N	N	N	N
Preference for dry air	P (Slight)	P (Slight)	P (Very)	I	P (Very)	I	I

Explanation of symbols:-

P- Positive

N- Negative

I- Indifferent.

VI. ACKNOWLEDGMENT AND BIBLIOGRAPHY.

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Diagram 1.-- Diagrammatic profile of the stations studied.

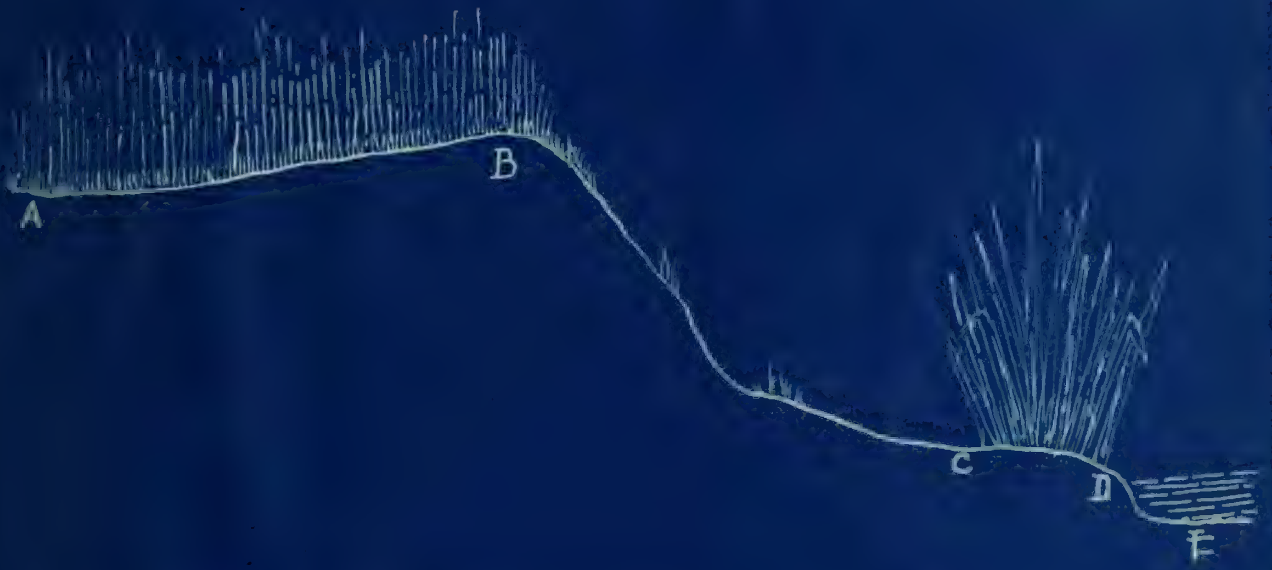
A-B, The Sweet Clover Association.

B-C, The Clay Bank Association.

C-D, The Brook Margin Association.

E- , The Temporary Marsh Association.

Diagramatic Profile
of
Stations Studied.



A-B··Sweet Clover Association.

B-C··Clay-Bank "

C-D··Stream Margin "

E- Marsh "

Explanation of Plate 1.

Fig. 1 - The Clay Bank, a type of situation selected by Dissosteira carolina.

Fig. 2 - A view showing a dry, barren path. At the right is the edge of the [illegible] Association. The vegetation at the upper left corner belongs to the Sweet Clover Association.

Plate I.

1

2

Explanation of Plate II.

Fig. 3 - Is a detailed view of the Sweet Clover Association, the habitat of *Melanoplus femur rubrum.*

Fig. 4 - Is a detailed view of the Brook Margin Association showing a growth of grass and smart weed shaded by willows. A typical habitat chosen by *Melanoplus differentialis*.

Fig. 5 - Is a detailed view of the temporary marsh, typical habitat of *Tetrix granulata*.

Plate II.

3

4

5